A STUDY OF PROPAGATION OVER THE ULTRA-SHORT-WAVE RADIO LINK BETWEEN GUERNSEY AND ENGLAND ON WAVELENGTHS OF 5 AND 8 METRES (60 AND 37·5 Mc./s.)*

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SUMMARY

The paper presents a survey and analysis of field intensity measurements obtained during the years 1937–1939, over the Post Office radio-telephone link between Guernsey and Chaldon, England, on wavelengths of 5 and 8 m. (frequencies 60 and 37·5 Mc./s.). The path between the stations was almost entirely over sea and about 85 miles in length, of which some 36 miles was outside the optical range. The data recorded have been analysed in such a way as to illustrate the general and detailed variations in received signal strength, and the manner in which these are dependent on various atmospheric conditions.

The results of the analysis have shown that while the fading of the signals was similar in type on the two wavelengths, there was a difference in the secular variation of the amount of fading on 5 and 8 m. No diurnal or seasonal variation of signal intensity was noted, nor was there any definite diurnal variation in the amount of fading. The fading observed took various forms, ranging from a rapid type in which the changes occurred more or less periodically every three or four minutes, to a slow type of variation extending over one or more hours. The latter type was usually accompanied by a high level of signal intensity interrupted at long intervals by rapid and deep fading lasting from 10 to 30 minutes. The field strength records show a marked correlation between periods of negligible fading and the existence of low atmospheric pressure conditions generally, including lack of appreciable temperature inversion. The occurrence of fog and snow has a similar effect to that due to the prevalence of low pressure.

A consideration of these results and of similar data obtained by other workers leads to the conclusion that abrupt changes in temperature and water vapour gradients in the atmosphere give rise to signal variations in good weather, while the absence of these discontinuities in bad weather allows of steadier signal conditions.

(1) INTRODUCTION AND PREVIOUS WORK

It is now well known that the ionosphere plays a negligible part in the propagation of very short radio waves in the metre band and below. There are instances on record of communication over considerable distances on wavelengths of about 5 m., but these are generally associated with abnormal conditions of the ionosphere during certain portions of the sunspot cycle. In general, and for distances up to 100–200 miles, the propagation of metre waves is independent of ionospheric conditions, although it has been known for some time that such propagation is accompanied by variations in transmission conditions, and a certain amount of investigation of this subject has been carried out in the past, mainly in the United States of America. This work has included the study of propagation both over land and over sea, and at distances both within and beyond the optical range, but considerably more information is required before the facts accompanying ultra-short-wave propagation will be known in sufficient detail for the purposes of the radio-communication engineer. Hull,[1] Englund, Crawford and Mumford[2,3,4] and others have suggested that changes in atmospheric conditions affect the propagation of ultra-short waves, while Smith-Rose and McPetrie[5] pointed out that the mere decrease in density of the air with increasing height would cause a change in refractive index resulting in a bending of the rays towards the earth, although this bending was insufficient to account for many signalling ranges already obtained by others. Englund, Crawford and Mumford, however, showed that the variation in refractive index, and so the bending of the rays, is materially affected by the presence of water vapour in the atmosphere.

The suggestion that ultra-short-wave propagation over land was influenced by weather was first made by Hull, who studied the reception of signals on a wavelength of 5 m. under a variety of conditions. He observed high signal intensities in the presence of temperature inversion, with a decrease in intensity at the onset of precipitation; he also found a diurnal variation with maximum values at sunset, and a seasonal variation with a high level in summer. The decrease in intensity during bad weather was often accompanied by rapid fading with a period of the order of one minute, and this was attributed to the turbulent state of the atmosphere. Englund, Crawford and Mumford, in studying propagation over land within optical range, obtained a similar diurnal variation, a seasonal effect with more fading in summer and a decrease in fading in bad weather. Waynick,[6] in propagation to just beyond optical range over land in England, found again a diurnal variation of fading, and a correlation with early morning observations of temperature inversion. Further experiments conducted by Englund, Crawford and Mumford over sea at distances beyond the optical range, indicated that fading was dependent upon weather conditions, but they found no diurnal variation either of mean signal level or of its fluctuation. These authors have constructed a fading pattern of the slow or roller type discussed later [type (*d*), page 14] for propagation beyond optical range, by considering the superposition of a direct ray and a series of indirect rays formed by reflections from the ground and the lower layers of the atmosphere. The height of reflection was assessed at about 2 km. from an analysis of the patterns obtained in some frequency sweep experiments on a wavelength of 5 m. Elsewhere, Colwell[7] has discussed the effects of temperature-inversion layers at various

*Wireless Section paper. Official communication from the National Physical Laboratory.

low heights, pointing out that rays reflected from the higher layers will require less hops than those from the lower layers, and will therefore be stronger and cause more fading.

(2) MATERIAL AVAILABLE FOR PRESENT INVESTIGATION

In the present paper an analysis is made of reception conditions at the English end of the Post Office radio-telephone link between Guernsey (C.I.) and Chaldon, Dorset, over a period of some two years from 1937 to 1939. For the majority of this period the above radio circuit was used as a multi-channel duplex link connecting the land-line telephone system in Great Britain with that in the Channel Islands. A description of the equipment and aerial systems used at the Guernsey and Chaldon stations has been given elsewhere by A. H. Mumford.[8] The transmitter at Guernsey was at a height of 270 ft. above sea level, while the corresponding height of the Chaldon receiving station was 500 ft. The transmission path was almost entirely over sea and covered a distance of about 85 miles, of which 36 miles was beyond the optical range. Two wavelengths of 5 and 8 m. (frequencies 60 and 37·5 Mc./s.) were used on this link; horizontal polarization was used on the 5 m. wavelength, while the 8 m. transmission was conducted with vertically polarized waves.

The material placed at the authors' disposal by the Radio Branch of the Post Office consists of continuous records, 24 hours per day, of signal-to-noise ratio measured at Chaldon on the transmissions from Guernsey on each of the two wavelengths referred to above. The records actually give a measurement of the current in the first detector stage of the receiver, a variation in this current of 0·25 mA corresponding to a change in signal field intensity of 15 db. Extreme changes of up to 60 or 80 db. have been recorded. No special meteorological observations were carried out, but the information provided in the Daily and Upper Air Weather Charts published by the Meteorological Office, Air Ministry, have been used extensively for correlation with the radio records.

(3) TREATMENT OF AVAILABLE DATA

An outstanding feature of the records studied is the wild and apparently erratic nature of the variation of the received field intensity at the receiving station. On some days the incoming signal is approximately constant in amplitude for periods of from a few minutes to several

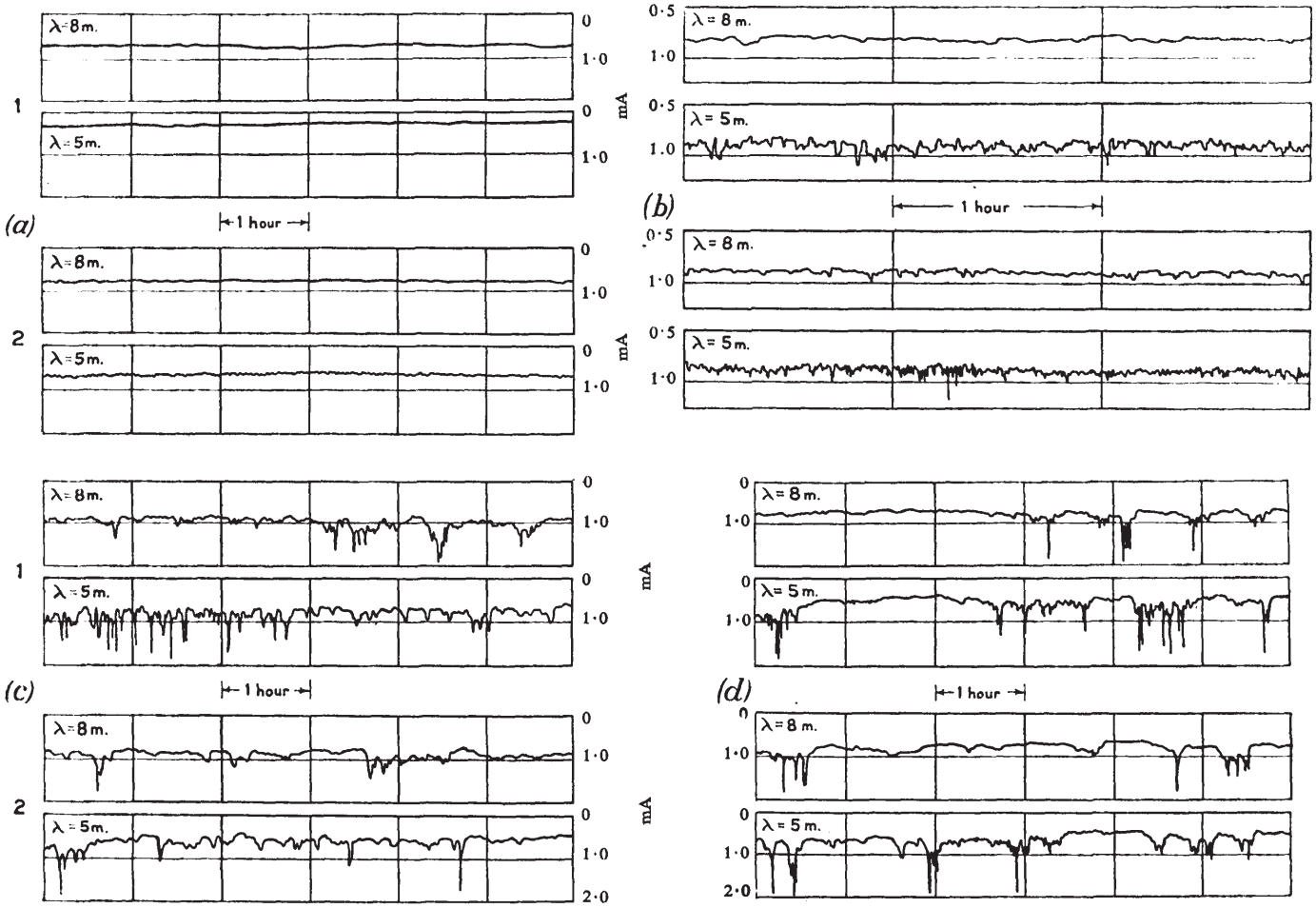

Fig. 1.—Samples of various types of fading.

(*a*) 1. Flat in presence of fog.
2. Flat.
(*c*) 1. Medium.
2. Medium with trace of slow.
(*b*) Rapid (mainly on 5 m.).
(*d*) Slow.

hours at a time, while on other occasions the signal intensity is varying at a period and over an amplitude, both of which range over very wide limits on different occasions. With a view to investigating the nature and cause of these variations a certain amount of preliminary reduction work had to be carried out on the received intensity values taken from the records themselves. To this end the mean intensity of received signal has been assessed for each hour, and from this a mean value for each day. A change in field strength of 15 db. from the daily mean has been taken as the minimum variation which shall constitute the presence of fading; and the total duration of fading of this or greater amplitude has been determined for each hour of each day. Other more complicated methods of determining the fading were investigated, but the results were very similar, and the simpler method was therefore used throughout.

Samples of the signal records are shown in Fig. 1, in which the main types of signal intensity variation have been broadly classified as follows:—

(*a*) "Flat record," with no variation, or only a very slow and small change over a period of a few hours;

(*b*) "Rapid fading," with an approximate period of less than 4 minutes;

(*c*) "Medium fading," with an approximate period of from 4 to 10 minutes;

(*d*) "Slow fading," a typically recorded variation, comprising stretches of relatively high intensity lasting from half an hour to two hours, followed by more or less sudden and deep troughs with rather rapid fading lasting from 10 to 30 minutes.

It will be realized from the description of type (*d*) that the mean intensity during slow fading will usually tend to be rather high, with occasional large variations in value. This feature is borne out in plots of daily values which show that there is a definite tendency for peaks of intensity, peaks of fading and slow fading to occur together (see Fig. 2).

(4) OBSERVATIONS ON GENERAL SIGNAL LEVEL

There is no definite regular variation either in the general level ot the intensity or in the amount of fading about this level. A certain amount of similarity is apparent between the two wavelengths, not in the appearance of the continuous records, i.e. the instantaneous variations, but in the general day-to-day variation both of intensity and of fading, and in the type of fading which occurs. This can be seen from the specimen records shown in Fig. 1, and is referred to again in connection with Fig. 4. There is no diurnal or seasonal variation in intensity, although there is a slight variation of about 5 db. in general level throughout the whole period of observations. Consecutive days may show a change of level of as much as 20 db., while instantaneous changes of level may amount to 60 to 80 db. on occasions.

When graphs are plotted of the mean value for each day, curves are obtained for each wavelength which show decided peaks at intervals varying mainly between 20 and 30 days with a mean value of 23 days. These peaks are to a very large extent coincident on the two wavelengths and are of magnitude 10 to 20 db. from peak to trough. They are somewhat irregular in occurrence and are usually of larger amplitude on the 5 m. than on the 8 m. wavelengths.

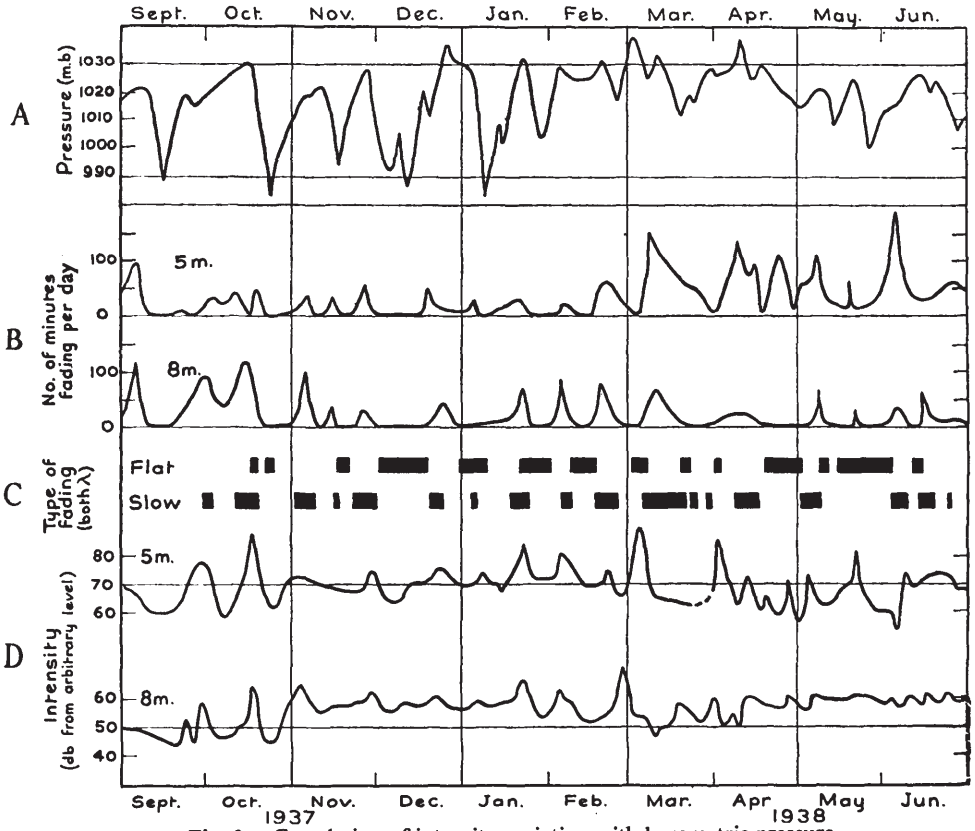

Fig. 2.—Correlation of intensity variation with barometric pressure.

Fig. 2(D) shows these mean daily values over a period of some months.

Peaks and troughs of intensity do not rigidly correspond to a definite type of fading, but minima of intensity are due mainly to two types:—

(*a*) Flat or lack of fading; and

(*b*) Medium associated with some slow fading.

The variation of mean level of intensity from hour to hour is very small for the (*a*) type of record but is rather high for the (*b*) type. Maxima of intensity occur predominantly at times of slow fading, sometimes with medium fading superposed, but they also occur occasionally at times of steady signal.

(5) ANALYSIS OF FADING

For purposes of analysis, the amount of fading has been assessed as the number of minutes in each hour when the signal varies by more than 15 db. from the mean level for the day. In general, fading computed on this basis is similar in type and amount on the two wavelengths of 5 and 8 m.; although there is no exact correlation in the times of peaks and troughs of intensity, the same type of record usually occurs in any given day for both wavelengths. This is seen in the specimen records of Fig. 1, which also show that the fading tends to be more rapid on the 5 m. than on the 8 m. wavelength. This difference is particularly noticeable in (*b*), where rapid fading is superposed on a "flat" trace in the 5 m. record but is almost imperceptible in the 8 m. trace.

(5.1) Seasonal Variation

In general, the amount of fading is much greater in summer than in winter, although the variations in the two years under review are by no means similar. The monthly mean curves show a decrease in fading in winter on both wavelengths and a peak about July, but the variations from month to month are so wide and different on the two wavelengths that no general inferences can be drawn as to annual variation over the short period at present available. There is, however, one interesting difference between the behaviour on the two wavelengths. It was noticed at first that fading was more severe on the 8 m. transmission, but that during 1938 the 5 m. signals became the more affected. In investigating this effect it was necessary to ensure that the presence of any seasonal change in amount of fading would not mask a longer-period variation; monthly means were therefore deduced over every period of 12 consecutive months (12-month running means). It was then found that on 5 m. the amount of fading shows a smooth increase, appearing to tend to a maximum in August 1938, while on 8 m. there is a correspondingly smooth decrease, with fading appearing to tend to a minimum in September–October 1938 (Fig. 3). In order to investigate whether there is anything of note in this feature, it would be necessary to have observations made over a much longer period. It would appear, however, that there is some long-term factor which either affects propagation on these two wavelengths in opposite ways or has a period which varies with the wavelength.

(5.2) Diurnal Variation

The daily plots and the monthly totals both of amount of fading and of number of days with more than 5 or 10

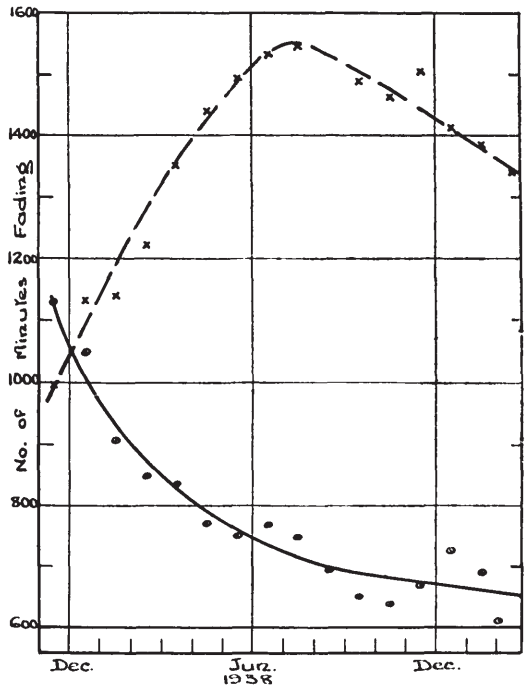

Fig. 3.—Secular variation of fading.
(12-month running means).
× — — × λ = 5 m.
⊙———⊙ λ = 8 m.

minutes' fading in each hour show no diurnal trend. When, however, the totals for the whole period under review are added, a definite diurnal variation is noticed. Examination shows that this is mainly due to the presence of such a variation in summer, the larger values of fading then giving a predominance to these months. On replotting the totals obtained by treating each month on a percentage basis, no obvious regular variation is noticeable, and it is therefore concluded that there is no real diurnal effect.

(5.3) Types of Fading and Annual Variation

Discussion of the main types of fading is of necessity vague, since the four types specified merge into each other or are overlaid during a large percentage of the time, but on the vast majority of days fading of the same type occurs on both wavelengths. The most outstanding types are the flat and the slow, although there is often slight medium fading superposed on these, especially perhaps in the reception on a wavelength of 5 m., and in the case of slow fading. Both these types occur for periods up to a week at a time, and there is a tendency for flat periods to end in one or more days with predominantly slow fading. Exact statistical statement as to occurrence of the different types of fading is difficult because the border-line between them is vague and two or more different types often occur on the same day. Plots have been made of days on which only one given type occurs, also of days on which there is some of the given type present. The results are indicated in the Table, which is a summary of 637 observations.

The relatively large proportion of days on which rapid fading is present on 5 m. is due to a characteristic fluctuation of amplitude, usually small with a period of from

Table

PERCENTAGE FREQUENCY OF OCCURRENCE OF VARIOUS TYPES OF FADING

Type	One type only present			Some of given type present		
	λ=5 m.	λ=8 m.	Both λ	λ=5 m.	λ=8 m.	Both λ
Flat ..	14	24	12	53	68	50
Rapid .	1·3	0·2	0·2	45	19	17
Medium	7	9	4	53	49	39
Slow ..	17	16	11	63	56	51

half to one minute; this mainly occurs on 5 m. and only in the winter.

The presence of the various types of fading during the year is shown in graphs giving the monthly distribution of the quantities shown in the above table (Fig. 4). These

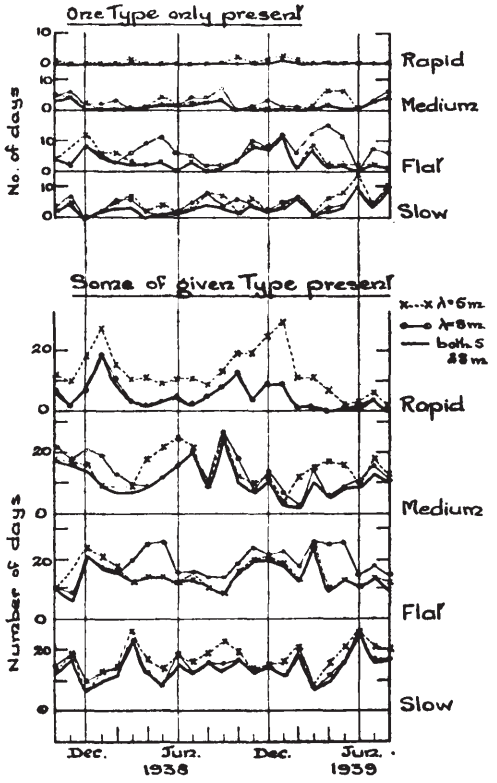

Fig. 4.—Relative frequency of occurrence of the various types.

indicate maxima in January for rapid fading, especially on 5 m., maxima for flat records in December–January on both wavelengths, and also in April on 8 m. The distribution of slow fading is not so marked as the flat, but there is a distinct inverse correlation between the two distributions. The large amount of correlation between the two wavelengths is shown by the closeness in each case of the curve for "present on both wavelengths" to the lower individual curve, which is more frequently the one referring to the wavelength of 8 m.

(6) CORRELATION WITH PHYSICAL QUANTITIES

(6.1) Data Studied

The presence of fading as a general feature of the records under consideration indicates the probable presence of at least two paths for the rays passing from transmitter to receiver. The possible means of propagation are by direct path, with bending due to the combined effects of diffraction around the curved surface of the earth, and refraction due to variation in the dielectric constant of the atmosphere with height, and by indirect path produced by refraction or reflection from above. At the short wavelengths under consideration reflection from the ionosphere will not occur, and we are therefore led to consider reflections from layers in the earth's lower atmosphere.

The maximum straight-line path between two points at heights of 270 ft. and 500 ft. respectively, is 49 miles, so that the stations at Guernsey and Chaldon, 85 miles apart, are well outside optical range of each other, and for a ray to pass direct from transmitter to receiver it must suffer bending equivalent to a radius of 1·5 times that of the earth. It will then form an arc tangential to the earth and will therefore never reach a height above the earth greater than that of the transmitter or receiver. For the direct ray we thus need to consider the atmosphere below 500 ft., while, for the indirect ray, variations at heights of one to two miles may affect propagation.

The chief physical factor in the atmosphere which would affect wave propagation is the gradient of dielectric constant with height, and this is directly connected with variation of pressure, temperature and water vapour content at different altitudes. Sea-level data for these quantities are available from meteorological records taken at 6-hourly intervals at Guernsey and at Portland Bill, which is near Chaldon; but the only regular upper-air measurements available for the period 1937–1939 are those taken at Mildenhall, an inland station, mainly in the early morning with a certain number at midday. The sea-level data comprise pressure, temperature, wind and humidity, while the upper air data give variation with height (deduced from pressure) of temperature and humidity, together with notes of observed temperature inversions, up to heights of 2 to 3 miles. Variations of atmospheric pressure at the two ends of the path are very similar, though the pressures are not identical in absolute level; it therefore seems certain that readings at one end will give a very good indication of conditions over the whole path. More detailed sea-level data such as temperature, rainfall and fog vary somewhat from one station to the other and, as remarked, temperature variations with height are only available at a station some distance from the path.

(6.2) Results of Correlation

In the correlation of radio and meteorological data it has been found practicable to compare day-to-day variations of signal with day-to-day variations of weather as indicated by the pressure at ground level, rather than to select days of outstanding signal character and study the corresponding weather characteristics (or vice versa). This is due to the fact that meteorological data, especially of the upper air, are not available over the actual path under consideration. In this way an immediate connection is seen between prolonged periods of low pressure and steady signal (Fig. 5). Steady or "flat" records occur when the

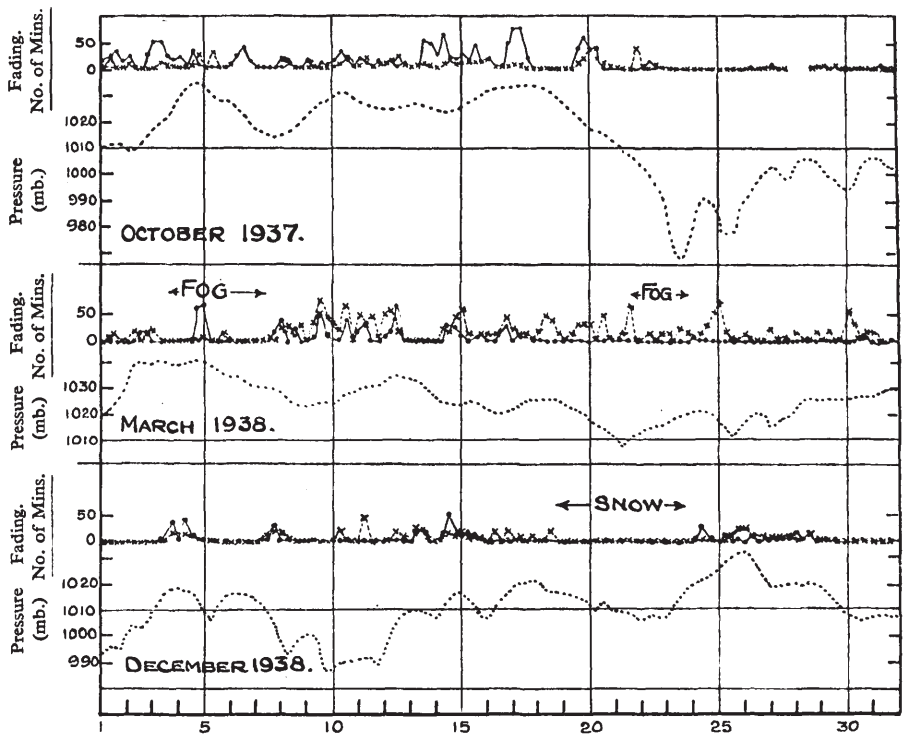

Fig. 5.—Correlation of amount of fading with pressure, fog and snow.

× — — × λ = 5 m.
● ——— ● λ = 8 m.

pressure remains below about 1 015 millibars (mb.) for more than a day. The "limiting" pressure varies somewhat through the year, being slightly higher (1 020–1 025 mb.) in the spring (January–April) and lower 1 010–1 015 mb.) in the summer (June–September). From March to June the signals on a wavelength of 5 m. do not respond to this pressure variation in the same way as do the 8 m. signals. There are three main exceptions to this correlation throughout the period studied, viz. flat records were present with high pressure during snowy periods, thick fog, and on one other occasion which appears to have no outstanding characteristics except early morning fog. On the other hand, peaks of pressure often correlate with peaks of intensity, with which are frequently associated maxima of fading, and the type of fading described as "slow," or "roller" in the terminology of American workers (Fig. 2). At these times there are frequently temperature inversions near the ground, and temperature inversions at heights above 1 000 ft. are often recorded in the early morning at Mildenhall, while on days characterized by steady signal and low pressure there is a lack of temperature inversion, particularly above 1 000 ft.

It has been remarked that although steady signals are consistently more prevalent in winter than in summer the results of the two years under review are very dissimilar. It is concluded, therefore, that the apparent seasonal variation is probably entirely contingent upon the greater frequency of low-pressure systems in winter and is not a seasonal variation in the usual sense. The rapid fading noticed on 5 m. signals in bad weather may be due to a shimmering effect caused by the turbulence of the atmosphere. This was also thought to be the case by Hull.

In considering the significance of these correlations, various meteorological facts must be borne in mind. Apart from the effect of diffraction, any bending or reflecting of rays must be due to changes in the constants of the atmosphere through which they pass, causing either a continuous change in refractive index throughout the path or sudden changes at some definite points of the path. The former would occur during the passage of the direct ray from transmitter to receiver, and the latter would be due to reflection at some discontinuity in the atmosphere.

(7) THEORETICAL TREATMENT

(7.1) Atmospheric Conditions and Ray Curvature

As has already been pointed out,[5] a ray traversing an atmosphere of refractive index varying with the height follows a curved path with a radius of curvature, ρ, given by

$$\rho = -\mu \Big/ \frac{d\mu}{dh}$$

where μ is the refractive index of the air at a height h and is related to the dielectric constant κ by the equation

$$\mu = \sqrt{\kappa}$$

Under normal conditions the dielectric constant, and so the refractive index, decreases with increasing height, so that a ray traversing strata of increasing height is bent downwards towards the earth.

In the case of the earth's atmosphere, we have to consider a mixture of air and water vapour, varying according to the prevailing temperature, pressure and relative humidity. It can be shown from the accepted theory of Debye[9] of polar molecules, and from the experimentally determined values of the dielectric constants of dry air and

of water vapour under specified conditions,[10] that the dielectric constant of moist air is given by the relation

$$\kappa = 1 + 210 \times 10^{-6}\frac{p_1}{T} + 180 \times 10^{-6}\left(1 + \frac{5\,580}{T}\right)\frac{p_2}{T}$$

where p_1 and p_2 are the partial pressures of dry air and water vapour respectively in mm. of mercury, and T is the absolute temperature. It is clear from this equation that a variation in the water-vapour content will have a marked effect in varying the dielectric constant of the medium and so the bending of wireless waves passing through it.

Special conditions may also occur in the region of temperature-inversion layers, where the normal decrease of temperature with increasing height may be suspended or even reversed, and where, associated with the sudden change in temperature, large changes in relative humidity may occur.

(7.2) Application of Theory

In applying the above simple theoretical considerations to the case of wave propagation, account must be taken of the various paths by which a ray can pass from transmitter to receiver, being subject to diffraction, refraction or reflection on the way, and to the possible interference effects which may result from the arrival of two rays simultaneously by paths of varying effective length.

(7.2.1) Direct Path.

Since in the case of the Guernsey to Chaldon radio link some 36 miles of the path are beyond the optical range, it is clear that a direct ray could only pass from transmitter to receiver by bending due to either or both diffraction and refraction. In the absence of specific knowledge on the subject, let us assume in the first place that temperature inversions are absent in so far as the direct ray path is concerned, and that therefore over the whole path there is a uniform variation of atmospheric conditions with height of the type found in a meteorologically "standard" atmosphere. This indicates that the bending of the direct ray by refraction will have a radius of curvature $R_1 = mR_0$, where R_0 is the radius of the earth, and m is a simple number which varies from 6 to 3, as the relative humidity increases from 0 to 100%. In a previous publication, T. L. Eckersley[11] has presented curves to show the effect of diffraction and a formula by means of which the additional refraction effect may be applied. It is clear that the direct ray will be subject to both of these effects, and that if the refraction component varies with alterations in atmospheric conditions the strength of the received signals will be subject to variation, or, in other words, the phenomenon of fading will be experienced. In a previous paper[12] the present authors have applied Eckersley's calculations to some of the experimental results obtained by the Post Office between Guernsey and England, and have shown that in at least a general way the range of variation of received signal strength may be accounted for by variations in moisture content, and so in refractive index, of the lower atmosphere along the direct ray path.

(7.2.2) Indirect Path.

Superimposed upon the direct ray path just discussed there may be one or more indirect rays. In this case we are concerned with the variation of refractive index of the atmosphere, probably due to change of dielectric constant caused by pressure, temperature and humidity changes; but now a variation is required sufficiently sudden to be in effect a discontinuity, and to give rise to a reflection or a refraction of very small radius of curvature compared with the radius of the earth. As stated above, the outstanding feature of comparison with the data is the variation of pressure. Now the upward gradient of pressure is difficult to determine from the pressure at ground level, so that we are led to study the associated phenomenon of temperature inversion, since meteorological data indicate that temperature inversions are always present in anticyclonic weather, and are usually absent in depressions, when there is greater turbulence in the atmosphere, resulting in more thorough mixing of the air and a lack of definite air boundaries. Due to the smaller thermal conductivity of land, inversions are more marked over land than over sea, and show a fairly strong diurnal variation which is absent over the sea. Large changes in water-vapour content are also associated with temperature inversions; although the knowledge at present available indicates that inversions over the sea are not so marked as those over land, it is possible that similar changes in water-vapour content are present in similar weather conditions. Remembering, then, that the results of the present investigation show a relation between steady signal, low pressure and lack of temperature inversion over land in the early morning, we may conclude that this condition corresponds to lack of reflection from the atmospheric layers and that the opposite condition of high fading in anticyclonic conditions is due to reflection from boundaries caused by sudden changes in water-vapour content due in part to an inversion of the normal atmospheric temperature gradient.

The study of some specific instances of presence of temperature inversion and the associated humidity changes shows that such reflection is possible, and as, in the case under consideration, the incidence of the rays on the atmospheric layers is very nearly grazing, the reflection coefficient will approximate to unity. Most of the data studied refer to inversions occurring at heights of about 4 000 ft.; these are often of the order of 4 or 5 deg. C., with a decrease of relative humidity from, say, 100% to 50% in passing upward through the inversion. Meteorological data are available only at intervals of 1 500 ft., but inversion is probably a sudden effect, so that we may assume that it occurs over a range of the order of a few tens of feet. In this case, normal decrease of temperature would be occurring over the rest of the range, and thus the actual inversion will be greater than the figures show. If, then, we assume a range of 50 ft. for the given value of temperature change, an approximation to fact may well be obtained. In this way it is found that the radius of curvature of the ray is of the order of 1/20 that of the earth, or 250 miles. Assuming a slightly curved path to and from the region of inversion as a first approximation, it is found that reflection is geometrically possible at heights greater than about 2 000 ft., and that the bending of radius 250 miles required to be equivalent to reflection from a height of 4 000 ft. must take place over a horizontal range of 5 miles and a vertical range of 50 ft. Both these ranges are within those obtaining in normal meteorological conditions.

If we consider humidity variations similar to the above

but with no temperature inversion a radius of curvature at reflection of about 300 miles is obtained. This would still be within admissible range.

Reflected or refracted rays are therefore possible from regions of discontinuity of dielectric constant present in the atmosphere, and these will thus combine with the direct ray to give variable signals on the usual interference basis.

(8) DISCUSSION OF RESULTS AND CONCLUSIONS

From this examination of the two years' records of the received field strength of signals transmitted over the Guernsey to Chaldon radio link, a number of general conclusions emerge, indicating that the variations of signal intensity are definitely influenced by the weather conditions prevailing over the path. There is considerable similarity in the type of fading observed on the two wavelengths of 5 m. and 8 m. used on this link, except that there appears to be a difference in secular variation which indicates that there may be some long-term factor, the effect of which varies with the wavelength. No diurnal or seasonal variation of mean signal intensity is observed, or any definite diurnal variation of fading. During periods of high atmospheric pressure, the signal intensity is usually at a maximum accompanied by much fading of the slow type; it is to be noted also that temperature inversions often occur at these times. During periods of low-pressure conditions, with very little temperature inversion, the received field intensities are found to be steady although rather low in level. Similar steady-signal conditions also occur in the presence of snowy or foggy weather even on occasions when the atmospheric pressure is high.

The results summarized above would appear to confirm and supplement those obtained by other workers, notably in America, studying the propagation of ultra-short waves over land or sea. It seems clear that the main agencies causing variations in signal intensities on these wavelengths are the variations in refractive index of the air in the lower atmosphere, due notably to changes in moisture content, and in addition the presence or absence of temperature inversion layers from which the waves can be reflected at heights of from a few hundred to a few thousand feet. A more detailed study of the radio phenomena on these lines has not been possible on account of the limitations imposed by the nature of the meteorological information at the place and for the period of the wireless observations. It is expected, however, that in future investigations this limitation may be at least partly removed, by improved meteorological technique for studying conditions in the lower atmosphere, and by making arrangements for special and close co-operation between those responsible for the wireless and the meteorological observations.

(9) ACKNOWLEDGMENTS

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[The discussion on this paper will be found on page 20.]